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TO: Gene Deschamps

FROM: Betsy Dickes *Betsy Dickes*

SUBJECT: Black River Water Quality, Winter, 1989/1990

INTRODUCTION

A water quality screening study on the Black River (Thurston/Grays Harbor Counties) was performed from November 1989 through June 1990. It was initiated by the Department of Ecology's Surface Water Investigations Section subsequent to the summer 1989 fish kill. Concern had been growing regarding the river's ability to meet Class A water quality standards (Appendix A) with the cumulative effects of four fish farms on the river, land-use activities such as agriculture and logging, as well as the increasing population in the watershed. After the fish kill, it became apparent that data was needed to better assess the river's ambient condition.

Study objectives were:

1. To begin collecting baseline water quality data as soon as possible;
2. To evaluate the need for a more intensive study from the data obtained; and
3. To provide technical assistance in water quality sampling to the Chehalis Indian Tribe.

This memorandum describes the methods, results, conclusions, and recommendations of this study.

Study Area Description

The Black River is a 28 mile river which flows through Thurston and Grays Harbor Counties. It drains 136 square miles before flowing into the Chehalis River (Phinney and Bucknell, 1975). Land use in the area is primarily agricultural and residential, with logging activity in the Black Hills. The river has a low gradient, about five feet/mile (Ecology, 1989). Much of the river is largely pool areas, with pool-riffle areas found near Littlerock and in the lower seven miles. Channel width ranges from 5 to 30 yards. The river supports one of the largest riparian wetland systems in the state (White, 1990). It provides habitat for fish, wildlife, and native plants, including six wildlife species considered species of concern by the Washington Department of Wildlife (Cyra, personal communication). The river also provides recreational opportunities such as swimming, fishing, and boating.

METHODS

Mid-stream grab samples were collected at three sites: river mile (RM) 1.1 (Howanut Road bridge), RM 7.1 (Moon Road bridge) and RM 18.4 (Littlerock bridge) (Figure 1). Sample collection was performed monthly during the study period by Chehalis Indian Tribe Fisheries personnel between approximately 9 and 11 a.m.; samples were not collected in February due to flooded roadways. Samples were immediately iced and stored in the dark. Conductivity, pH, and dissolved oxygen (D.O.) were analyzed by Ecology personnel in Olympia within three hours of collection. Samples for laboratory analysis were delivered within 24 hours to the EPA/Ecology Environmental Laboratory in Manchester, Washington.

At this time, there are no USGS gages on the Black River. The magnitude of wet weather flows renders the river unwadable, and therefore we opted not to measure discharge.

Quality Assurance/Data Analysis

Replicate samples were taken at one station each month to assess combined field and analytical variability; the replicated station was chosen via a rotating schedule. The average of the replicate samples was used in subsequent calculations. Relative percent difference, the difference between two replicates expressed as a percentage of their mean, was used to measure the similarity of replicates. After reviewing the data it appeared that total suspended solids (TSS), fecal coliform bacteria (FC), and chemical oxygen demand (COD) were more variable than remaining parameters. The variability in TSS was most likely due to sample heterogeneity. The variability in FC was most likely due to natural patchiness. COD replicates, though more variable than TSS and FC, never exceeded a relative percent difference of 20. In April, replicates for pH had a difference of 0.58 standard unit (S.U.). This variability was high, but the mean value of the replicates was still used in subsequent calculations.

Correlations between parameters were evaluated using Spearman rank correlation analysis. This is a nonparametric statistical test which makes no assumption of the underlying distribution.

Water quality criteria for metals are hardness dependent (U.S.EPA, 1986). Hardness was only analyzed in May and June 1990, therefore, the two-month average hardness value was applied to the metals data collected throughout the study period.

RESULTS

Tables 1 and 2 and Figures 2 and 3 summarize water quality data collected during the 1989/90 Black River study (raw data can be found in Appendix B). The river violated

Class A standards for pH, D.O., and FC at various times. Estimated values for lead and copper exceeded water quality criteria at the downstream site (Appendix C).

The pH of the river was usually at the lower limit of the criterion (6.5-8.5). This was not surprising given the organic acids which are characteristic of the boggy, slow moving river.

D.O. violated the Class A criterion of 8.0 mg/L at RM 7.1 during November, December, and June; the percent saturation of oxygen was also low during these months (Figure 2 and Appendix B). Of particular note are the low D.O. values found at RM 18.4 in November; the water is quite turbulent here and the low D.O. values were surprising. The cause of this is unknown. Oxygen saturation had a negative, moderate correlation to COD ($r = -0.76$, $p < 0.001$). It is unclear from the data what the COD source may be; FC and TP which are present in manure showed only a weak to moderate correlation to COD, $r=0.47$, $p=0.04$ and $r=0.56$, $p=0.01$, respectively.

Concentrations of FC tended to be highest at RM 7.1. However, in November and May the FC concentration at RM 1.1 was twice that found at the midstream site (Figure 2 and Appendix B). The Class A standard for FC (Appendix A) was violated on the river during November, January, and June:

	Nov	Dec	Jan	Mar	Apr	May	June
	(three sites combined)						
GEOMETRIC MEAN: (#/100 mL) :	147	15	229	36	10	39	396

Violations were also observed when data at each site were pooled over the study period (Table 2). Viewing the data from this perspective showed that the Class A standard was violated at sites RM 7.1 and RM 1.1.

Generally, TSS and turbidity increased downstream. During a January storm event the levels of suspended solids and turbidity were greatly increased at RM 18.4, then decreased dramatically by RM 7.1 (Appendix B). This observed decrease could be due to sedimentation in the less turbulent downstream reach.

Nutrient concentrations were lower at the upstream site RM 18.4 compared with RM 7.1 and RM 1.1. RM 18.4 had significantly lower nitrate concentrations relative to RM 1.1 (ANOVA, $p < 0.001$). This increase downstream may result from human influences such as agriculture. TP was highly and significantly correlated to FC ($r=0.86$, $p < 0.001$) during the study; this often occurs when fresh manure washes off to surface waters. Turbidity and TSS were also highly and significantly correlated to total phosphorus (TP) ($r=0.83$, $p < 0.001$ and $r=0.74$, $p < 0.001$, respectively), which reflects the adsorptive nature of phosphorus. Ammonia did not reach toxic levels during the study period.

Estimated values for total recoverable lead and copper at RM 1.1 exceeded state water quality criteria (U.S.EPA). The laboratory qualified the concentrations with a 'J' (Appendix C), which means they are estimates (that is, they were above detection limits and reproducible, but below the laboratory's reporting levels). Using the two-month average hardness value in calculating toxicity values adds an additional margin of error.

CONCLUSIONS/RECOMMENDATIONS

RM 18.4 and RM 7.1 experienced violations of the state's water quality criteria for dissolved oxygen. It is unusual to have D.O. violations during winter months in western Washington; this implies that more severe conditions could occur during the low-flow summer months. From the data collected in this study, in addition to the low reaeration potential of a slow moving river, I recommend that an investigation be performed to characterize dissolved oxygen conditions during low flow.

Water quality violations on the Black River were observed for FC during this wet weather study. More intensive sampling needs to be initiated to identify sources and begin implementation of management techniques to control fecal loading to the river.

The high TSS and turbidity at RM 18.4 during the January storm event warrants further investigation. These levels may result from land-use activities in the vicinity or upstream of the sampling site.

Estimated concentrations for total recoverable lead and copper exceeded state water quality criteria. Because of the uncertainty of the values, I recommend that metals and hardness be analyzed during any future water quality work performed on the Black River. Using 20 mg/L $CaCO_3$ as a minimum hardness reference in the calculation for toxicity (U.S. EPA, 1986), the detection and reporting limits should be: 0.1 ppb for cadmium and lead; 1.0 ppb for copper; and 10 ppb for chromium, nickel, and zinc.

Flow data has not been collected on the river for years. This study did not measure discharge due to unavailability of stream gaging instruments for large rivers. I recommend that efforts be made to establish discharge measurements on the river so that loading information for nutrients, FC, and solids can be obtained.

Ecology will be performing a water quality assessment of the Chehalis River basin during winter and summer, 1991; limited water sampling of the Black River will be included. Existing data collected from this 1989/90 study, the ambient monitoring site at RM 7.1, and the Black River Citizens Monitoring group will be reviewed. The data will be used to assist in developing a sampling design for the Black River portion of the Chehalis project, as well as to establish the need for a more intensive Ecology summer study for the Black River.

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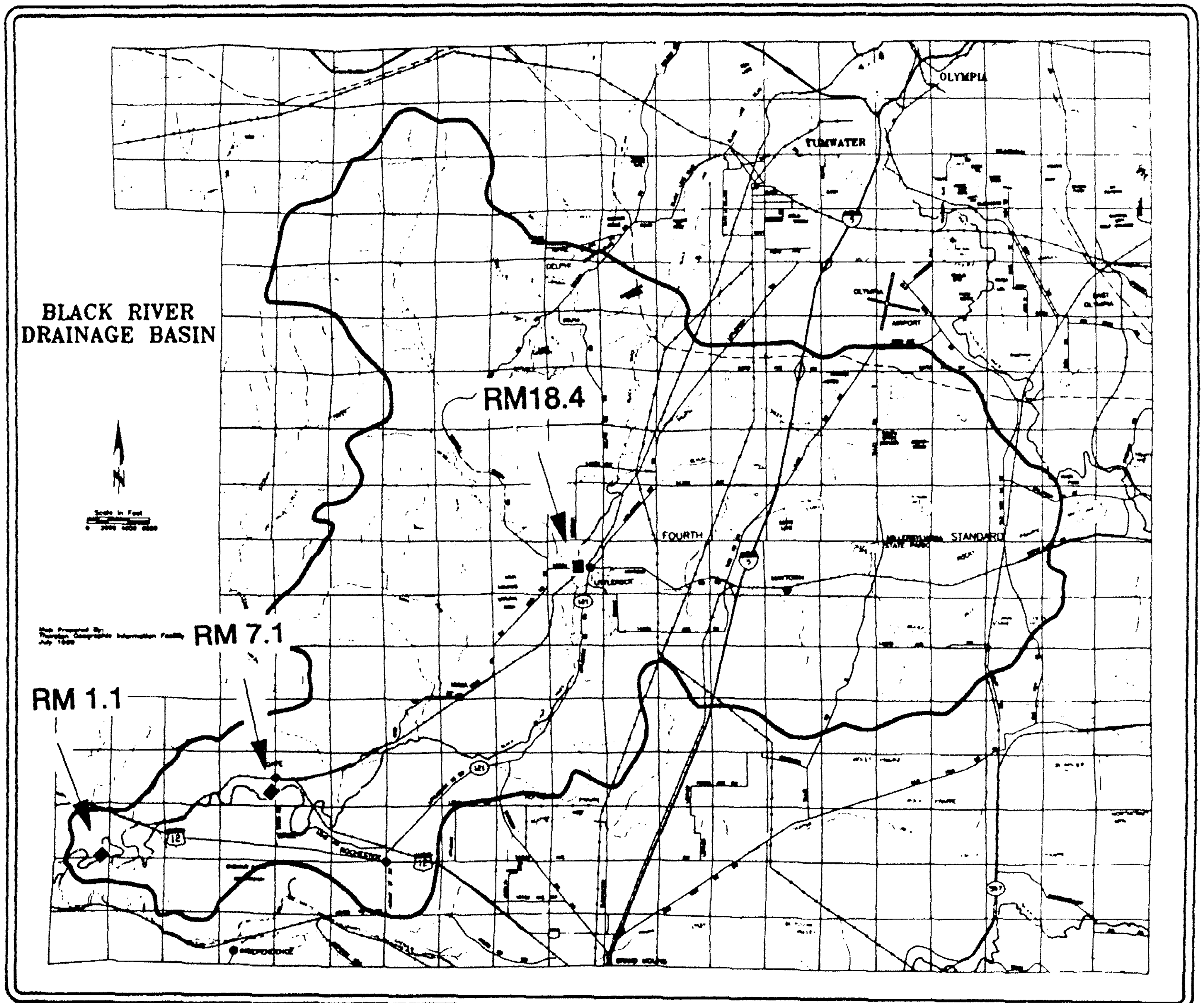

Figure 1. Map of the Black River showing sampling sites at river mile (RM) 1.1 (Howanut Road bridge), RM 7.1 (Moon Road bridge) and RM 18.4 (Littlerock bridge).

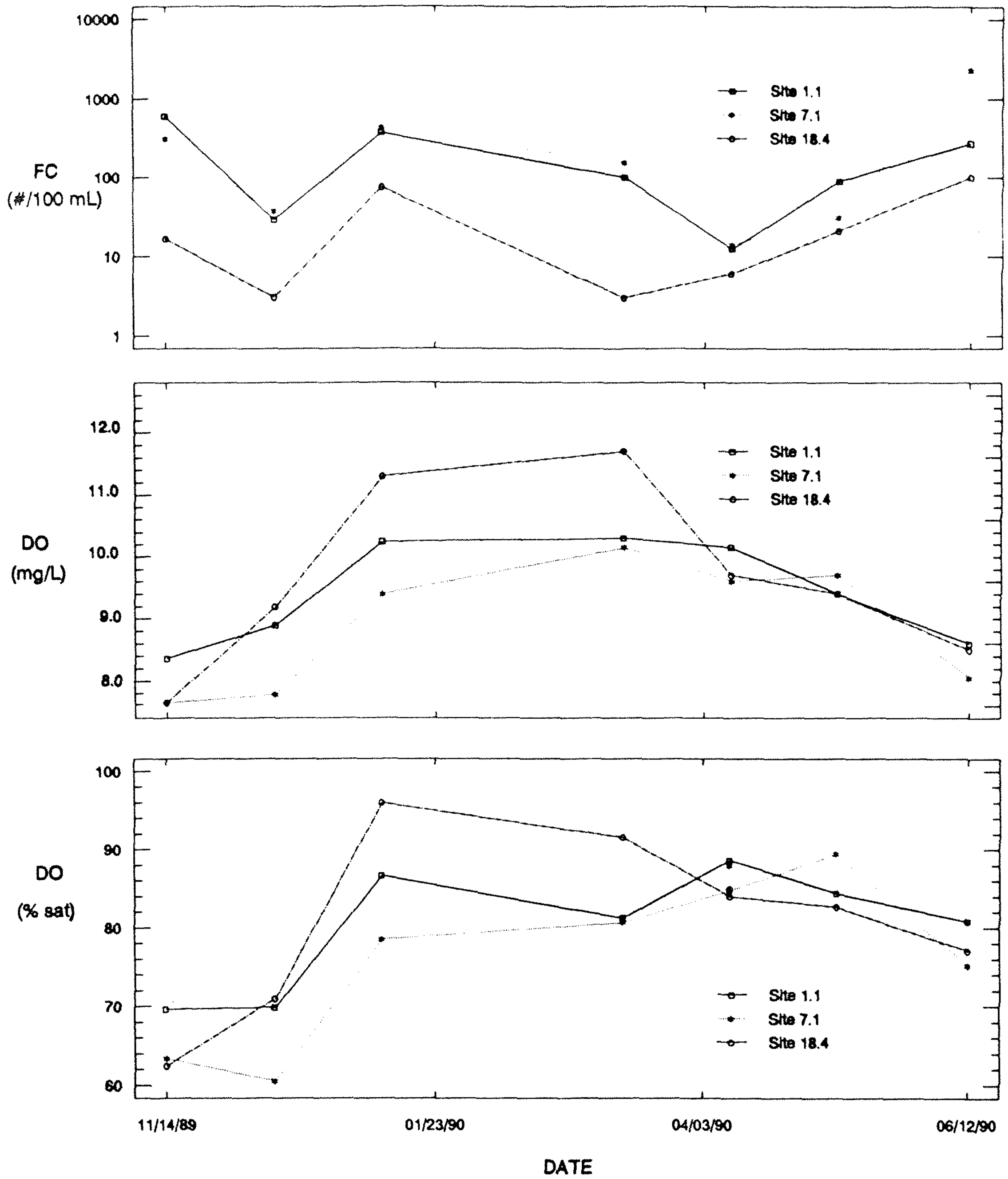

Figure 2. Mean concentrations of fecal coliform bacteria (FC), dissolved oxygen (D.O.), and D.O. percent saturation for sites RM 1.1, 7.1, and 18.4 on the Black River.

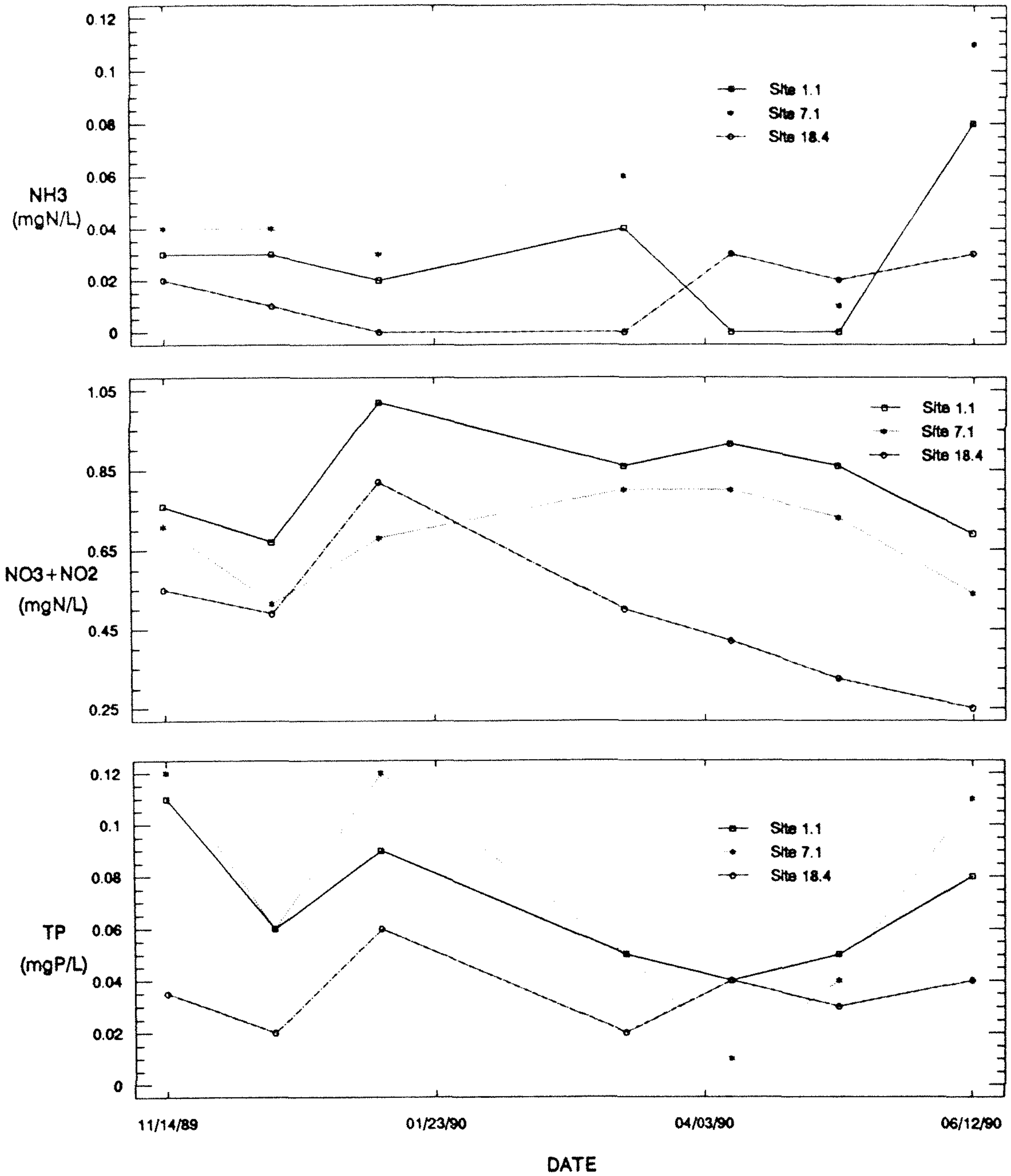

Figure 3. Mean concentrations of ammonia (NH3), nitrate+nitrite (NO3+NO2) and total phosphorus (TP) for sites RM 1.1, 7.1, and 18.4 on the Black River.

Table 1. Summary of water quality field data for the Black River survey November 1989 - June 1990.

Parameter †		SAMPLING SITE RM 18.4	RM 7.1	RM 1.1
Temp. (°C)				
	min.	5.3	5.8	6.0
	max.	11.7	13.0	13.2
	mean	8.4	9.2	9.1
pH (S.U.)				
	min.	6.5	6.5	6.3*
	max.	6.9	7.0	6.9
	med.	6.7	6.7	6.7
Cond (umhos/cm)				
	min.	35	50	59
	max.	88	84	98
	mean	60	68	78
D.O. (mg/L)				
	min.	7.6 *	7.6 *	8.3
	max.	11.6	10.1	10.2
	mean	9.5	8.8	9.3
D.O. (% sat)				
	min.	63	62	71
	max.	97	90	90
	mean	82	77	81

† Temp= temperature, Cond=conductivity, D.O.=dissolved oxygen
* violation of state Class A water quality standards

Table 2. Summary of laboratory water quality data for the Black River November 1989 - June, 1990.

Parameter †		RM 18.4	RM 7.1	RM 1.1
		SAMPLING SITE		
TSS (mg/L)				
	min.	1	1	3
	max.	150	8	24
	mean	23	4	7
Turb (NTU)				
	min.	1.0	1.3	1.4
	max.	39.0	5.6	16.0
	mean	6.6	2.3	3.9
NH_3 (mg N/L)				
	min.	<0.01	0.01	<0.01
	max.	0.03	0.11	0.08
	mean	0.02	0.05	0.03
NO_3+NO_2 (mg N/L)				
	min.	0.27	0.54	0.69
	max.	0.84	0.82	1.04
	mean	0.50	0.70	0.85
TP (mg P/L)				
	min.	0.02	0.01	0.04
	max.	0.06	0.12	0.11
	mean	0.04	0.07	0.07
FC (#/100 mL)				
	min.	3	14	12
	max.	100	2300	600
	geometric mean	15	130 *	110 *
COD (mg/L)				
	min.	12.3	11.6	12.6
	max.	34.7	33.3	28.8
	mean	20.9	22.1	19.4

† TSS=total suspended solids, Turb=turbidity, NH_3=total ammonia, $N0_3+N0_2$=nitrate plus nitrite, TP=total phosphorus, FC=fecal coliform bacteria, COD=chemical oxygen demand

* violation of state Class A water quality standards

Appendix A. Freshwater Class A (excellent) water quality standards (WAC 173-201-045) and characteristic uses.

General Characteristic

Water quality of this class shall meet or exceed the requirements for all or substantially all uses.

Characteristic Uses

Characteristic uses shall include, but not be limited too, the following: water supply (domestic, industrial, agricultural); stock watering; fish and shellfish; wildlife habitat; recreation; and navigation.

Water Quality Criteria

Fecal coliform bacteria: organisms shall not exceed a geometric mean value of 100 organisms/100 mL, with not more than 10 percent of samples exceeding 200 organisms/100 mL.

Dissolved oxygen: shall exceed 8.0 mg/L.

Total dissolved gas: shall not exceed 110 percent of saturation at any point of sample collection.

Temperature: shall not exceed 18.0°C due to human activities. Temperature increases shall not, at any time,exceed $t=28/(T+7)$. t=allowable temperature increase measured at a dilution zone boundary, and T=represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge. When natural conditions exceed 18.0°C, no temperature increase will raise the receiving water temperature by greater than 0.3°C. Temperature increases from nonpoint source activities shall not exceed 2.8°C, and the maximum water temperature shall not exceed 18.3°C.

pH: shall be within the range of 6.5 to 8.5, with a man caused variation within a range of 0.5 units.

Turbidity: shall not exceed 5 NTU over background turbidity when the turbidity is 50 NTU or less, or has more than a 10 percent increase in turbidity when the background is more than 50 NTU.

Toxic, radioactive, or deleterious material concentrations: shall be below those which may adversely affect characteristic water uses, cause acute or chronic conditions to the aquatic biota, or adversely affect public health (see WAC 173-201-047).

Aesthetic values: shall not be impaired by the presence of materials of their effects, excluding those of natural origin, which offend the senses of sight, smell,touch, or taste.

Appendix B. Water Quality Data from the Black River Study, 1989/1990.†

Date	Site	Temp (°C)	Cond (umhos/cm)	pH (units)	DO (mg/L)	DO (sat)	Turbidity (NTU)	TSS (mg/L)	NO_3+NO_2 (mg N/L)	NH_3 (mg N/L)	Total P (mg P/L)	FC (#/100 mL)	COD (mg/L)	Hardness (mg/L $CaCO_3$)
11/14/89	RM 1.1	8.3	78	6.82	8.3	70%	2.3	4	0.78	0.03	0.11	600	28.8	-
11/14/89	RM 7.1	8.2	72	7.00	7.6*	64%	2.2	5	0.73	0.04	0.12	310	33.3	-
11/14/89	RM 18.4	7.6	63	6.85	7.7*	64%	1.2	3	0.53	0.02	0.04	31	38.4	-
11/14/89	RM 18.4 REP	7.6	60	6.85	7.4*	62%	1.2	1	0.61	0.02	0.03	9	30.9	-
12/12/89	RM 1.1	6.0	60	6.79	8.8	71%	1.7	6	0.69	0.03	0.06	29	23.8	-
12/12/89	RM 7.1	5.8	64	6.68	7.7*	61%	1.3	5	0.54	0.04	0.06	34	27.6	-
12/12/89	RM 7.1 REP	5.8	64	6.64	7.7*	61%	1.5	3	0.53	0.04	0.06	40	22.5	-
12/12/89	RM 18.4	5.3	55	6.76	9.1	72%	1.0	3	0.51	0.01	0.02	3	20.5	-
01/09/90	RM 1.1	8.9	60	6.50	10.1	87%	17	33	1.03	0.02	0.09	330	19.3	-
01/09/90	RM 1.1 REP	8.5	58	6.65	10.2	87%	15	15	1.05	0.02	0.09	420 S	18.6	-
01/09/90	RM 7.1	8.3	50	6.55	9.3	79%	5.6	8	0.70	0.03	0.12	430 S	27.9	-
01/09/90	RM 18.4	8.8	35	6.74	11.2	97%	39	150	0.84	0.01 U	0.06	75	25.1	-
03/13/90	RM 1.1	6.0	65	6.27*	10.2	82%	1.8	4	0.88	0.04	0.05	100	17.9	-
03/13/90	RM 7.1	6.3	62	6.50	10.1	82%	1.9	3	0.81	0.06	0.05	130 S	21.1	-
03/13/90	RM 7.1 REP	6.3	55	6.49*	10.0	81%	1.9	2	0.83	0.06	0.05	180 S	18.1	-
03/13/90	RM 18.4	5.6	45	6.52	11.6	92%	1.4	3	0.52	0.01U	0.02	3	12.3	-
04/10/90	RM 1.1	10.0	100	6.40*	10.1	89%	1.4	2	0.94	0.01 U	0.04	14	12.1	-
04/10/90	RM 1.1 REP	10.0	95	6.98	10.1	90%	1.4	4	0.93	0.01 U	0.04	11	11.2	-
04/10/90	RM 7.1	10.5	73	6.72	9.5	86%	1.3	1	0.82	0.03	0.01	14	11.6	-
04/10/90	RM 18.4	9.7	88	6.85	9.6	85%	1.1	1	0.44	0.03	0.04	6	14.2	-
05/08/90	RM 1.1	11.2	93	6.87	9.3	85%	1.7	3	0.88	0.01 U	0.05	89	13.4	33.5
05/08/90	RM 7.1	12.3	84	6.46*	9.6	90%	1.5	1	0.75	0.01	0.04	31	14.4	-
05/08/90	RM 18.4	10.4	70	6.57	9.2	83%	1.1	2	0.34	0.02	0.03	21	14.2	-
05/08/90	RM 18.4 REP	10.3	70	6.68	9.4	84%	1.7	2	0.35	0.02	0.03	21	12.9	-
06/12/90	RM 1.1	13.2	90	6.84	8.5	82%	2.3	3	0.71	0.08	0.08	270	20.1	39.3
06/12/90	RM 7.1	13.0	83	6.93	7.9*	76%	2.1	3	0.56	0.11	0.10	2400 BOF,L	22.3	-
06/12/90	RM 7.1 REP	13.0	70	6.94	8.0	76%	2.0	4	0.56	0.11	0.12	2200 L	18.2	-
06/12/90	RM 18.4	11.7	65	6.87	8.4	78%	1.3	2	0.27	0.03	0.04	100	25.8	-

* violation of Washington State water quality standard (WAC 173-201-045)

† REP = replicate
U = detection limit
S = greater than
BOF = bottle over full
L = total plate count >200

Appendix C. Metals data (total recoverable) collected from Black River Study, 1989/1990 at RM 1.1.

	METALS (ug/L) †											
DATE	Cadmium		Lead		Chromium		Nickel		Zinc		Copper	
11/14/89	0.20	U	1.0	U	0.58		20	U	2.0	U	4.7	J
12/12/89	0.20	U	1.0	U	0.64		1.0	U	5.0	U	2.0	U
01/09/90	0.20	U	1.0	U	1.3	J	1.0	U	8.5	J	*5.1	J
01/09/90	0.20	U	*1.2	J	1.0	J	1.0	U	6.8	J	2.0	U
03/13/90	0.20	U	*1.5	J	0.76	J	1.0	U	6.4	J	2.0	U
04/10/90	0.10	U	1.0	U	0.48	J	1.0	U	5.0	U	2.0	U
04/10/90	0.10	U	1.0	U	0.44	J	1.0	U	5.0	U	2.0	U
05/08/90	0.10	U	1.0	U	0.95	J	1.0	U	5.0	U	2.0	U
06/12/90	0.10	U	*1.8	J	1.4	B	1.0	U	5.0	U	2.0	U
Chronic(b)	0.50		0.88		760		67		45		5.0	
Acute	1.3		23		90		600		50		6.8	

† U = detection limit
J = estimated value
(b) = water quality criteria based on 36.4 mg/L $CaCO_3$
* = exceeds water quality criteria (U.S. EPA, 1986)